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Study of Crane Hook Having Trapezoidal Section by Finite Element Method & Design of Experiments

Santosh Sahu[1], Ritesh Dewangan[2], Manas Patnaik[3], Narendra Yadav[4]
[1, 2, 3, 4](Department of Mechanical Engineering, Rungta College of Engineering & Technology, Raipur-492001-India

Abstract : *In the industrial processes Crane Hook is used as lifting member. In the present paper crane hook of trapezoidal section is modeled in CATIA V5R20, then 2 ton load equivalent to 19620 N on it is applied. The location of maximum stress produced within the member is located and identified using Finite Element Method (FEM). Further Design of Experiment (DOE) is applied by varying the length of two parallel sides of the Trapezoidal Hook and its effects are studied on the basis of Stress , Mass, Displacement and Energy stored within the hook.*

Keywords - *Crane Hook, DOE, FEM , Trapezoidal Hook, AISI 4140*

I. INTRODUCTION

Crane hook is the member used for lifting the mass using wire ropes and crane. In this paper we have used a CAD model of Trapezoidal section Crane Hook in CATIA V5R20 and assigned the material having mechanical properties of AISI 4140 used for manufacturing of crane hook . Finite Element Analysis is applied to find out the stress in the critical section where maximum stress is induced . Design of Experiments is applied in Matlab, by varying the parallel length of the trapezoidal section and its effects is studied in terms of Energy stored, displacement, stress induced and mass accumulated within the crane hook in the form of output parameters. The results obtained from Design of experiment is plotted to know the nature of the output parameters with respect to the varying parallel length of outer as well as inner surface. By this we established the relation between the cross section and the output parameters which are useful for selection of the cross section dimensions during manufacturing with respect to the desired output parameters .

II. CRANE HOOK DIMENSIONS AND MATERIAL

The CAD model of Crane hook is shown in Figure1.

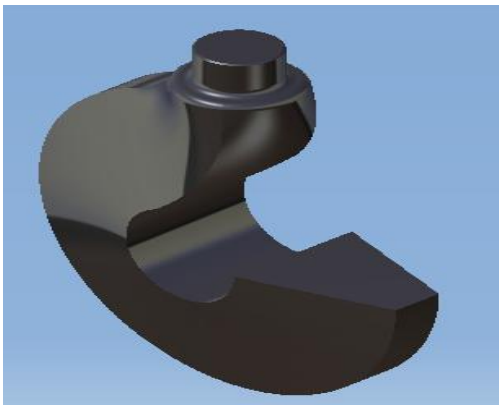

Fig.1 CAD Model of crane hook

The dimension of the trapezoidal section is shown in Figure2.

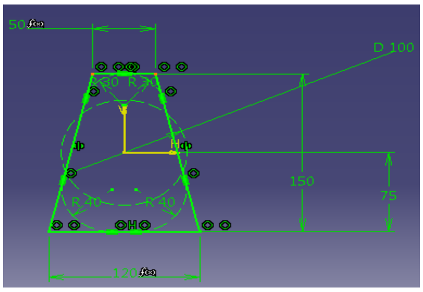

Fig.2 Dimensions of Trapezoidal section.

The material used for crane hook is forged steel the material selected in this cad model is AISI 4140 . The Mechanical properties of AISI is mentioned in Table 1.

Table 1. Mechanical properties of AISI 4140

MECHANICAL PROPERTIES	VAUES	UNIT
Elastic Modulus	2.05E+11	N/m^2
Poisson's ratio	0.285	N/A
Shear Modulus	8.00E+10	N/m^2
Density	7850	kg/m^3
Tensile Strength	560000000	N/m^2
Yield Strength	460000000	N/m^2
Thermal Conductivity	42.7	W/(m·K)
Specific Heat	477	J/(kg·K)

III. RESULT AND ANALYSIS BY FEM

The Finite Element Method is a Numerical Analysis Technique used to obtain solutions .Meshing is important part of Finite Element Method. The mesh details done in the CAD model is shown in Table. The mesh taken has Tetrahedron shape (Te4)

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Table 2. Mesh details

Entity	Size
Nodes	9163
Elements	40630

Von Mises Stress distribution in cad model is shown in Figure 3.

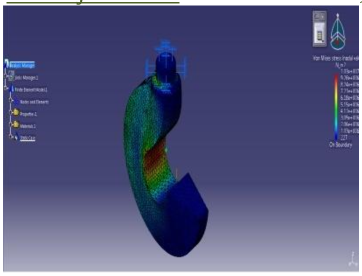

Fig. 3 Von Mises Stress Distribution

Translational displacement of nodes is shown in Figure 4.

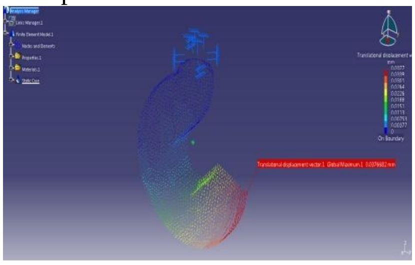

Fig. 4 Shows Translational displacement of nodes

The Sensors showing values of Energy, Maximum Displacement Maximum Von Mises' , and Mass obtained by FEM is shown in Figure 5.

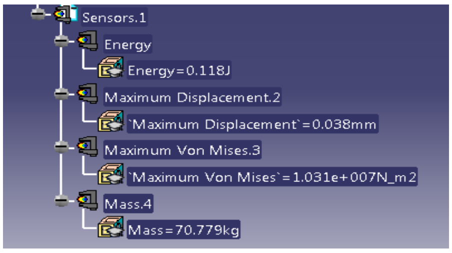

Fig. 5 Sensors Details after analysis

The maximum Von Mises stress location and magnitude is shown in Figure 6.

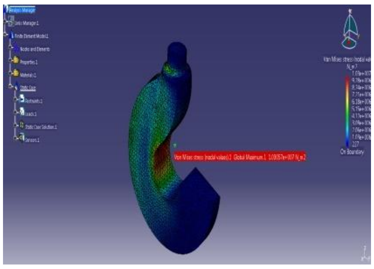

Fig. 6 Maximum Von Mises Stress.

IV. DESIGN OF EXPERIMENTS

DOE is Concerned with planning and conduction of experiments to analyze the resulting data by applying principles and techniques at the initial data collection stage to generate valid , defensible objective engineering conclusions .

we have taken two variable input values which are length of two parallel sides of Trapezoidal section namely' B' and 'b. The value of B which is at the inner side of the hook varies from 110 mm to 130 mm, whereas the value of b which is the outer side of the hook varies from 45 mm to 55 mm. Figure 7 shows the command window where input parameters B and b are assigned the minimum and maximum values and Output parameters are selected here are Energy, Maximum Displacement, Maximum Von Mises and Mass. DOE is then performed and the results in the form of Graph has been plotted.

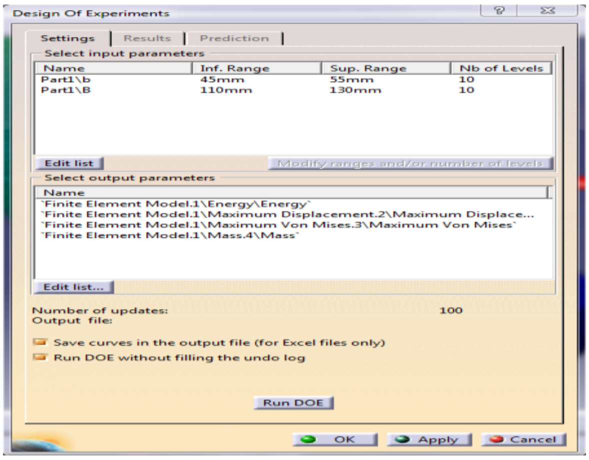

Fig. 7 Input Parameters and their Range With the selected output parameters

On running the DOE the results obtained are shown in the form of graphs between input variables and the selected output parameters

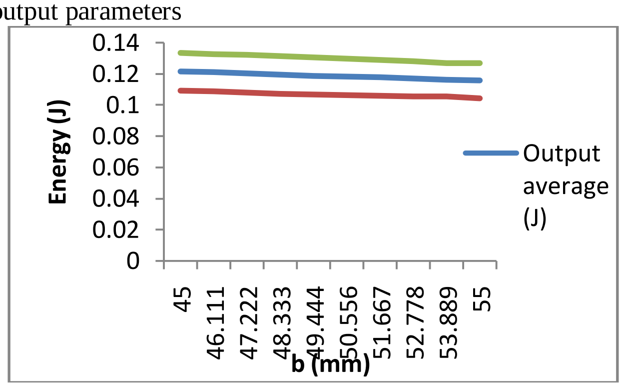

Fig.8 Graph Plotted Between Energy stored and b

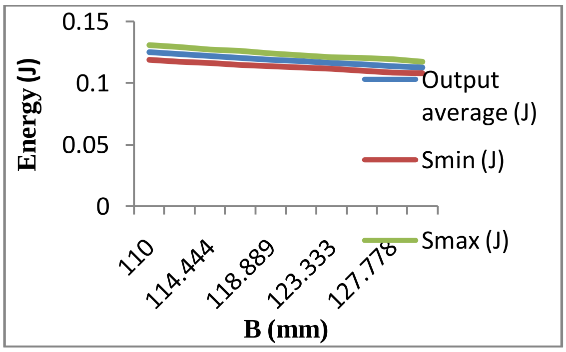

Fig.9 Graph Plotted Between Energy stored and B

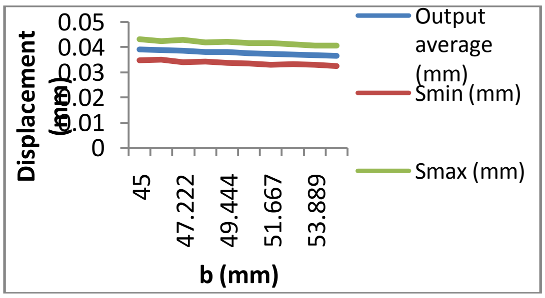

Fig.10 Graph Plotted Displacement and b

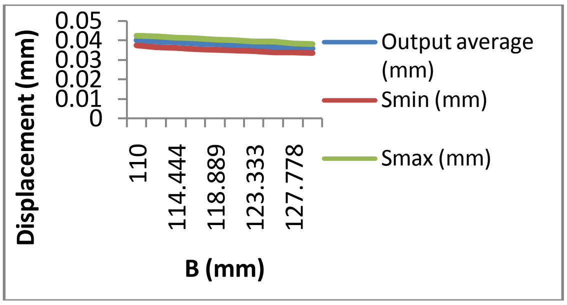

Fig.11 Graph Plotted between Displacement and B

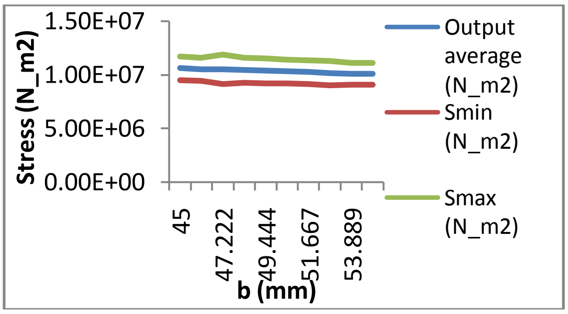

Fig.12 Graph Plotted between Stress and b

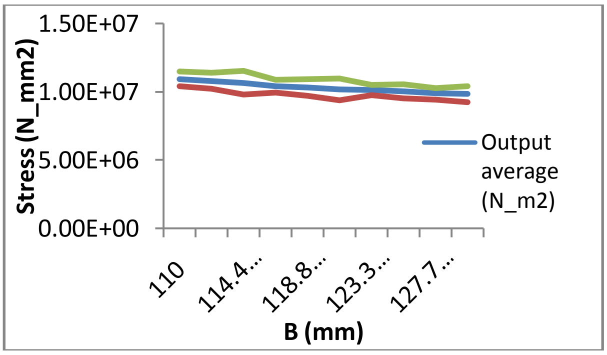

Fig.13 Graph Plotted between Stress and B

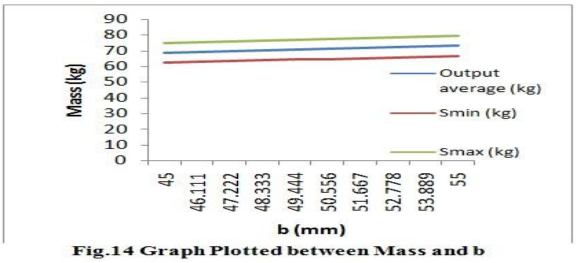

Fig.14 Graph Plotted between Mass and b

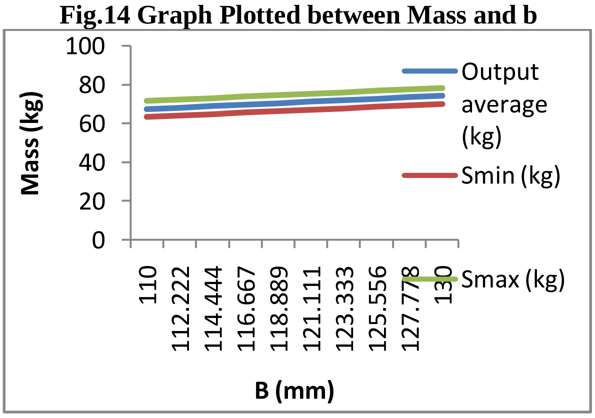

Fig.15 Graph Plotted between Mass and B

V. Conclusion

We have reached to the following conclusions on the basis of the results obtained from Finite element analysis and Design of Experiment performed for the trapezoidal cross section crane hook;

1. The Figure 6 shows the point where Maximum stress has been produced and the magnitude of maximum stress.
2. The Figure 8 shows the magnitude of energy stored within the crane hook decreases on the increase of outer parallel length (b) of trapezoidal section .
3. The Figure 9 shows the magnitude of energy stored within the crane hook decreases on the increase of Inner parallel length (B) of trapezoidal section .
4. The Figure 10 shows the magnitude of displacement within the crane hook decreases on the increase of outer parallel length (b) of trapezoidal section
5. The Figure 11 shows the magnitude of displacement within the crane hook decreases on the increase of inner parallel length (B) of trapezoidal section
6. The Figure 12 shows the magnitude of stress induced within the crane hook decreases on the increase of outer parallel length (b) of trapezoidal section
7. The Figure 13 shows the magnitude of stress induced within the crane hook decreases on the increase of Inner parallel length (B) of trapezoidal section.
8. The Figure 14 shows the magnitude of the mass of the crane hook increases on the increase of outer parallel length (b) of trapezoidal section.
9. The Figure 15 shows the magnitude of the mass of the crane hook increases on the increase of inner parallel length (B) of trapezoidal section

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